Fire Management notes

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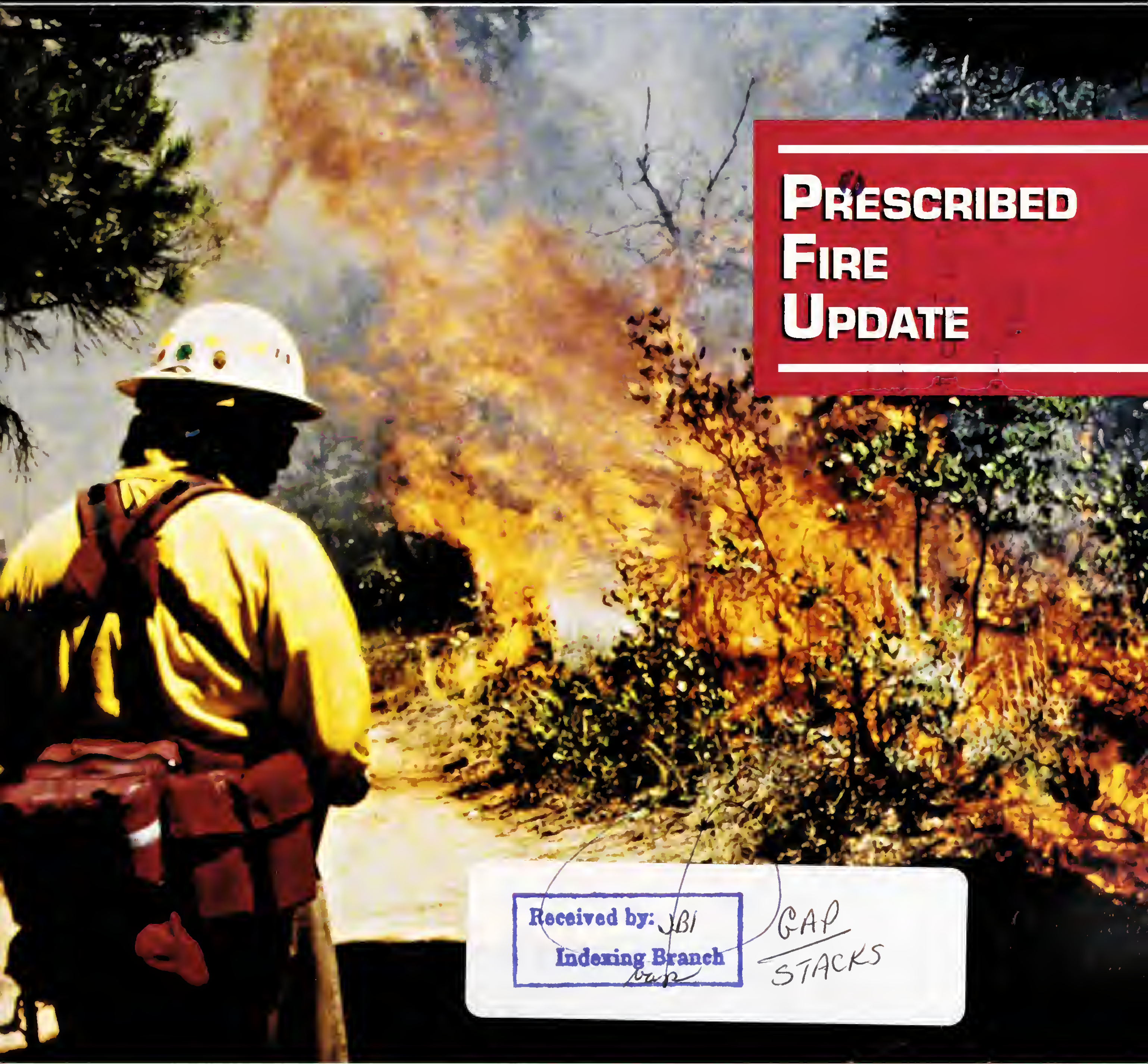

Prescribed Fire Update

United States Department of Agriculture
Forest Service

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On the Cover:

A Bandelier National Monument Fire Support Module member ignites a Zion National Park boundary burn in Utah. Photo: Pat Tolle, USDI National Park Service, Boise, ID, 1995. (See related article by Ben Jacobs beginning on page 4.)

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NPS Prescribed Fire Support Modules—a Pilot Program

Ben Jacobs

The fire community is becoming increasingly aware that decades of fire control in the United States, in combination with ineffective, large-scale prescribed fire applications, have produced unnatural levels of fuel accumulation in the Nation's parks and forests. In turn, fuel accumulation has created an increase in extreme and hazardous fire behavior events. Because these wildfires have become more costly and destructive than ever before, fire managers are looking at alternative management strategies to traditional fire control.

Land management goals of the United States Department of the Interior (USDI) National Park Service (NPS) call for the reintroduction of fire into the ecosystem by:

1) Using prescribed natural fire (PNF), which allows lightning strikes to burn freely in designated areas under specific conditions, or
2) Intentionally using management-ignited prescribed fire (MIPF).

Several barriers have hampered the restoration of fire to the ecosystem. One consistent obstacle has been the lack of available resources to ignite and manage burns during seasons of high wildfire activity. Many times, fuel and

In 1995, the National Park Service developed the Prescribed Fire Support Modules to accelerate prescribed fire programs and to reintroduce fire into ecosystems.

weather conditions during active wildfire years can also allow large-scale PNF's to burn across higher elevations. To manage these fires, experienced people are needed on the ground to monitor and predict fire behavior, map the perimeter of the fire, and check PNF's from spreading in undesirable directions.

Objectives of the PFSM

Lack of these experienced individuals led the NPS to develop the Prescribed Fire Support Modules (PFSM) as a pilot program. During the 1995 fire season, this crew was the only national resource solely dedicated to prescribed fire management in the United States. The broad mission of the PFSM is to assist the NPS in prescribed fire management, with particular emphasis on smaller parks without a permanent fire staff. In order of priority, the objectives of the PFSM are to:

- Provide monitoring assistance and make fire behavior predictions on prescribed natural fires.
- Ignite MIPF's.
- Prepare MIPF's by locating and constructing firelines, setting up

Using the Whiskeytown module to construct fireline on a Lassen Volcanic National Park burn. Photo: Pat Tolle, USDI National Park Service, Boise, ID, 1995.

Ben Jacobs is the Prescribed Fire Support Modules program coordinator, USDI, Branch of Fire and Aviation Management, National Interagency Fire Center, Boise, ID.

fire effects plots, performing archeological surveys, and writing burn plans.
- Perform mechanical hazard fuel reduction projects, which are some of the primary methods to reduce fuel loading in smoke-sensitive areas or immediately adjacent to structures.

The program was able to recruit 20 individuals with a variety of fire management experiences. There are four Prescribed Fire Support Modules—each with a leader, an assistant, and three crewmembers. In addition to strong suppression backgrounds at the single resource boss level, most modules had qualified prescribed burn bosses, ignition specialists, and holding specialists. The 1995 modules were located as follows:

- Bandelier National Monument, NM,
- Saguaro National Park, AZ,
- Whiskeytown National Recreation Area, CA, and
- Yellowstone National Park, WY.

One major aspect of the PFSM program was that the module personnel were unavailable for wildfire assignments, which meant the NPS always had experienced personnel available for prescribed fire management. Thus with assistance from the PFSM, the NPS is attempting to make the transition from suppression-based management to strategies that manage fire-endemic ecosystems in the healthiest way possible.

Role of the Program Coordinator

A program coordinator, located at the NPS Branch of Fire and Aviation Management at the National Interagency Fire Center in Boise, ID, scheduled and tracked the PFSM. Upon receiving requests for a module, the coordinator decided which module would respond to what project or PNF. As projects and burns were completed, the coordinator compiled the program accomplishments, and at the end of each month, circulated them throughout the NPS.

The Saguaro module puts the torch to a hazard fuel reduction burn at Golden Gate National Recreation Area. Photo: Pat Tolle, USDI National Park Service, Boise, ID, 1995.

The program coordinator was also the PFSM liaison to the National Interagency Coordination Center (NICC). Integrating the PFSM program into the interagency dispatching system required developing a new set of specific dispatching operating procedures.

Program Accomplishments and Future Direction

Twenty-eight NPS units used the PFSM during the 1995 fire season. In addition, the USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and California Department of Forestry and Fire Protection also used PFSM personnel on several burns. Several completed projects could not have been initiated without using the PFSM. The 1995 accomplishments of the modules are summarized in table 1.

Continued on page 6

Table 1—*1995 Accomplishments of the PFSM*

	Number of fires/projects	Total acres (ha)	Miles of handline (km)
PNF's monitored	6	2,165 (876)	______
MIPF's ignition	46	13,709 (5,548)	______
MIPF's preparation	42	______	27.5 (44.3)
Hazard fuel reduction	9	147 (59)	______

In general during its first year, the PFSM had a successful and smooth-running operation. The major goals and changes for 1996 are as follows (not in priority):

- Convert the eight PFSM module leader and assistant module leader positions from seasonal to permanent,
- Find ways to keep up with the numerous MIPF requests,
- Increase the Whiskeytown module size to seven people,
- Expand the interagency use of the program,
- Make personnel available for wildfires on a limited and rotating basis,
- Increase individual job skills with off-season training,
- Create opportunities for other NPS personnel to detail on the PFSM,
- Limit module road trips to 28 days maximum,
- Restructure module budgets to include all anticipated travel costs,
- Clarify and refine dispatching procedures with NICC and requesting NPS units,
- Purchase one new six-passenger crew utility vehicle for each module, and
- Move the Saguaro module to Zion National Park, UT.

As budget constraints allow, the above items will be implemented by the NPS Branch of Fire and Aviation Management before and during the 1996 fire season.

Conclusion

In the future, as Federal agencies look to enlarge their prescribed burning programs, the demand for dedicated prescribed fire resources will increase proportionally. Based on the 1995 program accomplishments and demand, there is a definite need to continue with the PFSM as a permanent fixture in NPS fire management. Having mobile and experienced modules available throughout the fire season should enhance attainment of NPS fire management goals for years to come.

For more information on the PFSM, contact Ben Jacobs at the USDI National Park Service, Boise, ID 83705, telephone 208-387-5219 or fax 208-387-5250. ■

Guidelines for Contributors

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Fire Management Notes (*FMN*) is an international quarterly magazine for the wildland fire community. *FMN* welcomes unsolicited manuscripts from readers on any subject related to fire management. (See the subject index of the first issue of each volume for a list of topics covered in the past.)

Because space is a consideration, long manuscripts are subject to publication delay and editorial cutting; *FMN* **does** print short pieces of interest to readers.

Submission Guidelines

Authors are asked to type or word-process their articles on white paper (double-spaced) on one side. Try to keep titles concise and descriptive; subheadings and bulleted material are useful and help readability. As a general rule of clear writing, use the active voice (e.g., Fire managers know . . . not, It is known . . .).

Submit articles to either the general manager or the editor. Complete details to reach them follow:

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Stand-Replacement Burn in the Ocala National Forest—A Success

George Custer and James Thorsen

In the spring of 1935, the fastest spreading wildfire in the history of the USDA Forest Service occurred on the Ocala National Forest in central Florida. This "Big Scrub Fire" was from a lightning set; it covered 35,000 acres (14,146 ha) in 4 hours with a rate of spread of 6 miles per hour (4 km/h). In May 1993, a stand-replacement prescribed burn in the same fuel type was completed in a fire-dependent ecosystem. These two ignitions have similar fuel types, fuel loads, and potential fire intensity; however, the planned prescribed fire met desired objectives to achieve stand replacement in a valuable ecosystem.

The Scrub Community

The prescribed fire was conducted in the sand pine (*Pinus clausa*) and scrub oak ecosystem, which is characterized as a xeromorphic shrub community dominated by an overstory of sand pine and a layer of evergreen oaks in the understory. On a normal site, total fuel loads range from 10 to 15 tons per acre (22 to 34 t/ha). The scrub community is unique because of its endemic plant species that occur nowhere else in the world. Many of these plants are listed as endangered or threatened. Along with the flora, the variety of animal species within this ecosystem is outstanding. Some animals from this community are on the Federal Endangered Species list, including the scrub jay (*Aphelocoma coerulescens*), the eastern indigo snake (*Drymarcnon corais*), gopher tortoise (*Gopherus polyphemus*), and the sand skink (*Neoseps reynoldsi*).

> Fire can be used in a stand-replacement process to maintain the forest ecosystem.

The sand pine and scrub oak community is restricted to well-drained sandy ridges and rises that burn infrequently. A hot and intense fire will normally kill the sand pine; however, the species is termed fire resilient because it has the ability to regenerate profusely following fire. The cones of sand pine are serotinous with the same characteristics as jack pine (*Pinus banksiana*), lodgepole pine (*Pinus contorta*), and giant sequoias in the West. The closed cones will open to release seeds only after intense heating.

To maintain this ecosystem, fire is required and can be used as a stand-replacing process to stimulate regeneration and reestablish the subclimax ecosystem. In general in this fire-dependent community, fire acts to stimulate flowering and seed production, enhance regeneration by exposing bare mineral soil, and reduce shading from woody understory species. It also removes fuel loading,

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Typical sand pine and scrub oak ecosystem and site before prescribed burn. Photo: George Custer, USDA Forest Service, Ocala National Forest, Umatilla, FL, 1993.

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releases nutrients to the soil, accelerates the herbaceous layer, and increases fruit and browse production.

New Initiative

On the Ocala National Forest, we normally use prescribed fire as a management tool in the majority of our ecosystems. In the sand pine and scrub oak ecosystem, prescribed fire is commonly used for regeneration after the merchantable sand pine is harvested from the site. Typically, a harvested site does not retain a high fuel accumulation compared to a mature sand pine stand. Therefore, stand-replacement prescribed burns are new; usually they occur only in association with a wildfire. With our approach to ecosystem management for natural resources, we conducted a complex prescribed fire that resulted in stand replacement.

We had two objectives for this type of prescribed fire: 1) to examine ecological trends and monitor, through research, the results of management activities to ensure that predicted conditions are achieved, and 2) to educate the public. We wanted to use this prescribed fire to aid in the understanding of how fire plays an important role in natural resource relationships and how the public perceives and values the protection, management, and use of our natural resources through a catastrophic fire of this type.

Because the Ocala National Forest is an urban forest in a heavily populated section of central Florida, prescribed fire is a risk in terms of excessive smoke, the possibility of fire escapes, and the threat to private property. A prescribed fire in this type of ecosystem where stand replacement is the objective can be a nightmare for land managers. We knew careful planning and testing the parameters for assurance of a successful prescribed fire was a must.

> Percentage of woody fuel moisture is essential for a successful prescribed burn.

Planning the Prescribed Fire

The most important element in achieving the objectives of any prescribed burn is a successful plan. In our case, planning covered not only weather and fire behavior, but more importantly, we wanted to select a site that would suit research needs and at the same time accomplish our objectives. We selected an area with good access for crews and equipment as well as forest roads on two sides. It was relatively small in size—30 acres (12 ha)—and posed few or no problems for smoke management, regardless of wind direction.

Establishing Plan Parameters

For the plan to work, this prescribed burn had to be characteristic of a catastrophic fire in the sand pine and scrub ecosystem: It had to be a fire of high intensity that would torch the crowns, consume 90 to 100 percent of the ground cover, kill all the overstory of sand pine, and produce enough heat to open the serotinous cones and regenerate the area. To achieve this

Dynamic fire behavior from head fire and flank fire. Photo: George Custer, USDA Forest Service, Ocala National Forest, Umatilla, FL, 1993.

type of fire behavior, the BEHAVE Fire Behavior Predictions System (Andrews 1986) was used to determine the parameters necessary. Of the 13 standard National Forest Fire Laboratory (NFFL) fuel models, Fuel Model 4 was used without any adjustments. This model is one of the shrub (or brush) fuel models in which fires generally burn with great intensity, are fast spreading, and involve the foliage and live and dead woody material. In ocala scrub, fires consume the ground cover, a continuous midstory of brush up to 8 feet (2 m) tall and often lead to crowning of the overstory of sand pine. The NFFL fuel model describes Fuel Model 4 as having a total loading of 13 tons/acre (32 t/ha), of which about 5 tons/acre (12 t/ha) is live fuel. The fuel bed depth is 6 feet (2 m). Since we needed an intense fire that would lead to crown consumption, we had to determine which flame length or fireline intensity would produce the desired effects.

Table 1—*Weather and fuel moisture parameters used to determine desired fire behavior in a prescribed burn*

1– Fuel model	4, in 6-foot (2-m) chaparral trees
2– 1-hour fuel moisture	8
3– 10-hour fuel moisture	9
4– 100-hour fuel moisture	13
6– Live woody fuel moisture	90, 100, 110, 120, 130
7– Midflame windspeed: mi/h (km/h)	2 (3), 4 (6), 6 (10), 8 (13), 10 (16)
8– Terrain slope	0
9– Direction-of-spread calculations: degrees clockwise from wind vector	0 (direction of maximum speed)

Flame length, feet (m)

Percentage of live woody fuel moisture	Midflame wind, miles per hour (km/h)				
	2.0 (3.2)	4.0 (6.4)	6.0 (9.7)	8.0 (12.9)	10.0 (16.1)
90	11.3 (3.4)	16.9 (5.1)	21.7 (6.6)	26.0 (7.9)	29.9 (9.1)
100	10.9 (3.3)	16.3 (5.0)	20.9 (6.4)	25.0 (7.6)	28.8 (8.8)
110	10.6 (3.2)	15.7 (4.8)	20.2 (6.2)	24.2 (7.4)	27.9 (8.5)
120	10.2 (3.1)	15.3 (4.7)	19.6 (6.0)	23.5 (7.2)	27.1 (8.3)
130	10.0 (3.0)	14.8 (4.5)	19.1 (5.9)	22.8 (7.0)	26.3 (8.0)

We used a table in chapter 6, section G, of the "Fire Behavior Field Reference Guide" (NWCG 1992), which helped to provide the answer. The height to the base of live crowns in the sand pine stand ranged from approximately 25 to 35 feet (8 to 11 m). This meant we needed to produce flame lengths of 9 to 19 feet (3 to 6 m), depending on moisture content, to get the intensity that would cause crown combustion. So we made several direct runs through the BEHAVE program. Because we found that woody fuel moisture and winds were the two dominate factors involved in the type of fire behavior we wanted, we determined our weather and fuel moisture parameters (table 1).

Through experience, we knew that wind was the one variable that could cause control difficulties. This was confirmed after running SPOT on the BEHAVE Program. Using a range of variables in SPOT from 90 to 130 percent live woody moisture and 2- to 10-miles per hour (3- to 16-km/h) midflame wind, we determined that spotting could occur at distances up to .9 mile (1.4 km) away on the high end. Even with a 4-mile-per-hour (6 km/h) wind at 90 percent fuel moisture, spots were possible up to .3 mile (.5 km) away.

Realizing that winds needed to be kept to a minimum, we determined that woody fuel moisture would rule our parameters; therefore, the prescribed fire would be accomplished with woody fuels below 110 percent, and minimal winds preferably in the 2- to 4-miles-per-hour (3- to 6-km/h) range. Table 2 shows the parameters for our prescribed burn plan. The next step in our planning process was to set up a fuels monitoring system. We followed the outputs from our National Fire-Danger Rating System (NFDRS) (Burgan 1988) station and started to measure our own woody fuel in a Compu-trac drying oven. On April 21, our NFDRS station showed woody fuel moisture at 143 percent. This was 4 days after a 0.41 inch (1.0 cm) rainfall. On May 1, we placed a rain gauge on the planned burn area and started measuring our own woody fuels on a daily basis.

From May 1 to 11, woody fuels were below 100 percent, already down into the range that we wanted, so on May 5, when the moisture content was 93 percent, we set a small test fire. Results indicated that the site was ready for a prescribed burn to meet our objectives.

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Active fire behavior with intensity reaching 1,100 Btu's per feet per second. Photo: George Custer, USDA Forest Service, Ocala National Forest, Umatilla, FL, 1993.

We then contacted all interested publics and partners involved with the replacement burn to inform them that the prescribed fire would be implemented soon.

Implementing the Prescribed Fire

Predicted weather for Tuesday, May 11, indicated that all conditions would be favorable for the prescribed burn. A trace of rain was recorded on the burn site on May 8, but we felt it would not affect our burning conditions. Table 3 demonstrates the predicted and actual weather conditions favorable for the prescribed burn.

In addition, our NFDRS (Burgan 1988) station, located 8 miles (13 km) east of our burn area, predicted fuel indices and fire danger for the prescribed burn (table 4).

Soil temperatures were monitored on site immediately following the prescribed fire for a study for the University of Florida. Photo: George Custer, USDA Forest Service, Ocala National Forest, Umatilla, FL, 1993.

Table 2—*Plan for Ocala National Forest prescribed burn using woody fuels below 110 percent*

	Region/ forest standard[1]	Prescription
1. Fuel model		4
2. Fuel sticks		8-11
3a. Windspeed 20 ft (6m)		5-12 mi/h (8 to 19 km/h)
3b. Windspeed - midflame		2-5 mi/h (3 to 8 km/h)
4. Wind direction		W, SW, S, SE
5. Relative humidity		35-50%
6. Temperature		95° F (35° C) or below
7. Keetch-Byram drought code		450 or below
8. Flame length		10-15 feet (3 to 5 m)
9. Ignition probability		70% or less
10. Scorch height		NA
11a. Days since rain		7 to 14
11b. Amount of rain		Less than .25 inches (.6 cm)
12. Firing technique		All
13. Ignition source/method		Aids torch
14. Burning Index		40 to 80
15. Mixing height		1,600 feet (500 m) or more
16. Transport wind speed		13 ft/s (4 m/s) or more
17. Direction		Any
18. Smoke dispersion		

[1]This column has been left blank because the standards have changed.

Table 3—*Predicted weather for prescribed burn on May 11, 1993, compared to onsite weather from 1000 to 1215 hours*

	Predicted weather	Actual weather
Maximum temperature	88° F (31° C)	79 to 82° F (26 to 28° C)
Minimum relative humidity	35%	51 to 46%
20-foot wind speed	12 mi/h (19 km/h)	Eye-level winds 2 mi/h (3 km/h)
Wind direction	Southeast	Southeast
Mixing height	4,500 feet (1,400 m)	
Transport wind speed	11 mi/h (18 km/h)	

Table 4—*The NFDRS station's predicted and actual measurements for fuel indices and fire danger*

	Predicted	Actual
1-hour fuel moisture	6%	7%
10-hour fuel moisture	7%	8%
100-hour fuel moisture	14%	13%
Woody fuel moisture	93%	91%
Burning Index	72	49
Ignition Component	32	16
Spread Component	21 chains per hour (1,386 ft/h) (422 mi/h)	16 chains per hour (1,056 ft/h) (322 mi/h)
Keetch/Byram Drought Index	450	457

The prescribed fire consumed 98 percent of the understory, and the majority of overstory was scorched through the crowns. Photo: George Custer, USDA Forest Service, Ocala National Forest, Umatilla, FL, 1993.

Firing Pattern and Fire Behavior

Before any fire was set, the whole prescribed fire organization gathered together onsite. We gave a thorough briefing, explaining each person's duties, the expected weather and fire behavior, contingency plans, and firing pattern.

We began firing the downwind or northwest side of the area first. Using short strip head fires placed about 20 feet (6 m) apart, we began to back the fire away from the lines. We continued this type of firing pattern until we had a black line about 2 chains (132 ft or 40 m) wide. During this phase of the firing operation, we had four small spot fires directly across the lines. They were all suppressed quickly, the largest covering an area less than 10 x 10 feet (3 x 3 m).

At approximately noon, we decided to use head fire to encompass the rest of the area because we had less than 10 acres (4 ha) on fire, producing flame lengths of 3 to 5 feet (1 to 2 m). Once the head fire was set, the remaining 20 acres (8 ha) were consumed in less than 20 minutes. Flame lengths averaged between 10 to 15 feet (3 to 5 m), with pockets of sand pine and individual trees torching through the tops of the crowns. During the high-intensity burning period when the head and flank fires were at their peak, the smoke column was very well defined. Smoke rose about 4,000 to 5,000 feet (1,000 to 2,000 m) and was white to dark in color with large emissions of particulate matter. The smoke could be seen from 15 to 20 miles (25 to 30 km) away. Drift smoke with ashes reached people on the ground 3 to 6 miles (5 to 10 km) from the site. During this phase, we did not experience any spotting.

Postburn Outcome

As soon as the smoke cleared at 1300 hours, we knew we had accomplished our objectives. Approximately 98 percent of the understory was consumed, leaving just leafless stubble. The overstory contained a small distribution of needleless sand pine with the majority scorched completely through the crowns.

Within days, sand pine seed could be seen falling from the open cones in the overstory. Approximately 30 days after the burn, the area showed young sand pine seedlings germinating and oaks sprouting from the consumed scrub oak stumps. Several of the threatened scrub endemics such as Florida Bonamia were flourishing under the open canopy, and at least one gopher tortoise had started a burrow within the burned area. Perhaps the most important outcome for local fire managers is the fact that the BEHAVE system (Andrews 1986) accurately predicted the fire behavior, resulting in a successfully executed prescribed burn with accomplished objectives.

The involved publics were satisfied with the outcome, and we continue to use the area as a "show

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me" stop for agency and public field trips such as Elderhostel and the Nature Conservancy. We have used our video and slides of the burn for numerous presentations to both public and agency groups. In addition, both agency and private researchers continued their studies (see Greenburg 1994).

Prescribed Fire for the Future

Historically, prescribed fire has played a major role in shaping and maintaining most of the ecosystems found on the National Forests in Florida and a large number of ecological communities in the Southeastern United States. Our present knowledge of prescribed fire is tremendous; therefore, the time is right for fire managers to demonstrate innovative management practices with prescribed fire to help restore the balance of nature and perpetuate healthy forests. A stand-replacement burn is one example; however, public support is needed along with public education.

Educational efforts aimed at ecological and social aspects are essential and should focus on:

- The natural cycle of vegetation growth and fuel accumulation;
- The use of preplanned prescribed fire and its influence on the environment for plants and animals;
- The effect of planned ignitions to reduce wildfire threats while enhancing forest health and esthetics;
- The use of prescribed fire to control fire behavior, intensity, location, and size, and to protect homes, improvements, and people, and
- Contacting, convincing, and cooperating with local government officials on the "why" of prescribed fire along with forming partnerships to achieve research goals and monitor efforts.

Smoke emissions were high in this small prescribed burn, but adequate atmospheric conditions resulted in no smoke management problems. Photo: George Custer, USDA Forest Service, Ocala National Forest, Umatilla, FL, 1993.

As we know, all prescribed fires can be risky. This stand-replacement burn in Florida demonstrated a new initiative and also showed how fire intensities can be extreme enough to cause concern for adequate preplanning and public participation.

As we learn more about the use of prescribed fire to reduce fuels and restore ecosystems, we are very aware that we will need to focus more on social impacts and fire effects.

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NVFC Offers Retention and Recruitment Video

The National Volunteer Fire Council (NVFC) has recently completed a 5-minute retention and recruitment video entitled "Volunteer Firefighters, They're People You Know." This motivational video highlights aspects of the volunteer fire service, showcasing urban search, rescue, and wildland firefighting tactics. The main focus is people who volunteer their time and effort to protect life and property. The video can also be personalized to a specific area by having the name and address of a local fire department added at the end.

For more information, contact the NVFC Resource Center National Office at 1050 17th Street NW, Suite 701A, Washington, DC 20036; telephone 202-887-5700, or fax 202-887-5291. The price of the video is $20.00 for nonmembers or $15.00 for members. ■

Survival of Fire-Injured Conifers

Paul Flanagan

Fires in eastern Washington burn at varying intensities, from slowly moving surface fires with low overstory mortality to wind-driven crown fires that scorch most of the tree crowns on the site. Studies of fire effects have shown that timing of conifer mortality ranges from immediate, where a crown is consumed by a fire; to a delay of a year after a fire, where cambial or root damage is extensive. Mortality from insects also ranges from immediate to a delay of several years.

The probability of a tree initially surviving a fire is related to the extent of damage to the crown, cambium, and roots. Conifers have various adaptations to fire, which increase the chance of survival or of rapid reseeding (table 1). Reinhardt and Ryan (1989) developed a generic model to estimate tree mortality (fig. 1). Saveland and Neuenschwander (1988) used diameter and scorch height to predict ponderosa pine mortality (fig. 2). Neither model includes subsequent mortality from bark beetles.

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Estimation of post-fire conifer survival depends upon many factors besides extent of fire injury. Bark beetles often elevate mortality rates significantly.

Active Douglas fir beetle larvae, showing egg gallery and larval galleries. Photo: USDA Forest Service, Forestry Sciences Lab, Wenatchee, WA.

Table 1—*Conifer resistance and adaptation to fire*

Conifer	Fire resistance	Adaptation to fire
Western larch	Very high when mature	Survive, produce light seeds for rapid regeneration
Ponderosa pine	High when mature	Survive moderate fires
Douglas fir	High when mature	Survive light fires when mature
Grand fir	Moderate when mature	Survive very light fires when mature
Western white pine	Moderate to low	Some survive light fires, reseed rapidly
Lodgepole pine	Low	Serotinous cones reseed rapidly
Whitebark pine	Low	Need regular fires for replacement
Mountain hemlock	Low	None
Western hemlock	Low	None
Western red cedar	Low	None
Subalpine larch	Low	None—often grows in talus slopes
Subalpine fir	Low	None
Pacific silver fir	Low	None
Noble fir	Low	None
Alaska yellow cedar	Low	None
Engelmann spruce	Low	None

$$P_m=1/(1/\exp(-(1.466 - 4.862\ B + 1.156\ B^2 + 0.000535\ C^2)))$$

P = predicted mortality;
B = bark thickness in inches;
C = percent of crown volume scorched

Figure 1—*Predictive model for tree mortality (Reinhardt and Ryan 1989).*

$$P=[1 + e^{(2.33 - 0.95x + .11y)}]-1$$

P = predicted mortality;
x = diameter at breast height (d.b.h.) in inches;
y = scorch height in feet

Figure 2—*Predictive model for ponderosa pine mortality (Saveland and Neuenschwander 1988).*

Streams of pitch indicate an attack by Douglas fir beetles. Photo: USDA Forest Service, Forestry Sciences Lab, Wenatchee, WA.

The attraction of bark beetles to fire-injured trees has been thoroughly documented. Western larch, the most fire-resistant conifer, has no major bark beetle associates. Mature ponderosa pines are almost as fire-resistant, but have several bark beetle associates that decrease the probability of survival. Douglas fir bark is resistant to fire when mature; however, the crown has a low base and is quite flammable, particularly when infested with Douglas fir dwarf mistletoe (*Arceuthbobium douglasii*). Douglas fir beetles (*Dendroctonius pseudotsugae*) are highly attracted to injured Douglas fir. The remainder of this discussion will focus on ponderosa pine and Douglas fir, conifers that may survive fire only to be killed by bark beetles.

Ponderosa Pine

The main cause of direct mortality in ponderosa pine following fire is crown scorch (Dieterich 1979). Cambial injury is significant when all four quadrants are injured in a tree with greater than 50 percent crown scorch (Mann and Gunter 1960). The deep roots of ponderosa pine roots are well insulated from heat; however, fine roots may be damaged if they grow into thick duff layers that develop as a result of decades of fire exclusion (Agee 1993).

Bark beetles attracted to fire injured ponderosa pine are the western pine beetle, mountain pine beetle, pine engraver beetle, and red turpentine beetle. Western pine beetle attacks infrequently produce pitch tubes, but commonly attract woodpeckers, which eagerly remove bark to obtain larvae from the meandering galleries. Mountain pine beetle attacks frequently produce pitch tubes but larvae are less frequently "woodpeckered." Galleries are long, vertical, with a J-shape at the bottom. These two species are the most aggressive of the bark beetles. Red turpentine beetles are highly attracted to fires and their attacks produce distinctive large red pitch tubes within 6 feet (2 m) of the ground. The localized cave galleries do not produce much girdling, and mortality from these beetles is rare. When evaluating bark beetle attacks, it is important to distinguish red turpentine beetle attacks from attacks by other bark beetles because of the low association with mortality even though the quantity and size of pitch tubes are often impressive.

Pine engraver beetles prefer smaller diameter pines (< 9" d.b.h.) (4 cm) and the tops of larger trees. These beetles, which produce forked galleries, are seldom responsible for significant mortality of medium and large pines.

Salman (1934) developed a scale (table 2) of increasing susceptibility to fire in the absence of bark beetle attack. Considering the

Table 2—*Ponderosa pine survival without bark beetle attack, in order of increasing risk of mortality (Salman 1934)*

Percent crown scorch	Cambium injury
0-25	None to slight
25-50	None to slight
0-25	Moderate to heavy
25-50	Moderate to heavy
50-75	None to slight
75-100	None to slight
50-75	Moderate to heavy
75-100	Moderate to heavy

probability of bark beetle attack, he recommended salvage if:

- Trees had > 50 percent crown scorch **and** moderate to heavy cambium injury;
- Trees had > 75 percent crown scorch **and** no or light cambium injury.

These guidelines will probably salvage more trees than would have died.

Miller and Keen (1960) studied the relationship between western pine beetle-caused mortality and fire-scorched ponderosa pine (table 3). As crown scorch increased, so did the percent of trees killed by western pine beetles.

Douglas Fir

Douglas fir is more easily injured by fire than ponderosa pine. There are at least three reasons for this:

- Douglas fir does not develop sufficient bark thickness until the second century of growth.
- Large lateral roots near the soil surface are more easily injured by ground fire (Ryan et al. 1988).

Table 3—*Relationship of crown scorch to mortality by western pine beetle (Miller and Keen 1960)*

Percent crown scorch	Percent of trees killed by western pine beetle
< 25	9-15
25-50	4-14
50-75	18-42
> 75	19-87

- Crowns are quite susceptible to scorch and crowning.

After a fire, Douglas fir with thick bark may be killed at the same or higher rate as those with thinner bark, because Douglas fir beetles are attracted to large diameter trees, even if they are only moderately scorched. Emerging adults then attack lightly injured or uninjured trees. Furniss (1965) found that most Douglas fir scorched in a fire in southern Idaho were subsequently infested by Douglas fir beetles (fig. 3). Two years after the 1988 Yellowstone fires, 67 percent of the fire-injured Douglas fir examined were infested by Douglas fir beetles. Forty six percent of the uninjured trees were infested.

A ponderosa pine attacked by western pine beetles and woodpeckers. Photo: USDA Forest Service, Forestry Sciences Lab, Wenatchee, WA.

Many of the fire-injured trees would probably have survived in the absence of beetles (Amman and Ryan 1991). Weatherby and others (1994) applied an equation developed by Reinhardt and Ryan (1989) to a fire in Idaho and found that many of the larger Douglas fir classified as survivors ultimately died from attacks by Douglas fir beetles.

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A maze of western pine beetle galleries. Photo: USDA Forest Service, Forestry Sciences Lab, Wenatchee, WA.

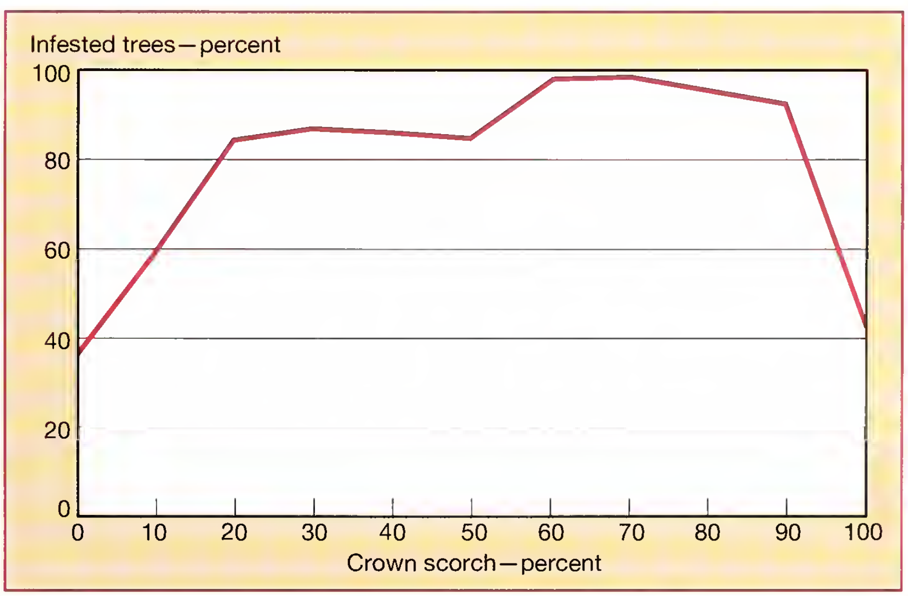

Figure 3—*Douglas fir beetle infestation related to crown scorch (Furniss 1965).*

Conclusions

Ponderosa pine can survive fire even if much of the crown is scorched—as long as the terminal and enough lateral buds survive and if the bole is not successfully mass attacked by western and/or mountain pine beetles. Caution should be taken to not salvage an excessive number of lightly to moderately scorched ponderosa pines and to avoid salvage that is based solely upon diameter.

Douglas fir over 12 inches (30 cm) in diameter that are scorched by fire have a moderate to high probability of being killed by Douglas fir beetles within 2 years. Inspection of cambium and roots for damage increases predictive accuracy.

Low intensity fire may lead to mortality from bark beetles. Photo: USDA Forest Service, Forestry Sciences Lab, Wenatchee, WA.

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Biswell Symposium Proceedings Published

The publication "The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems" is now available. The symposium was held in honor of Dr. Harold Biswell, a pioneer fire ecologist. The proceedings from the symposium include 38 invited oral papers and 23 poster papers describing current issues and state-of-the-art solutions to technical, biological, and social challenges facing land and fire managers. The Pacific Southwest Research Station's General Technical Report PSW-GTR-158 is available from:

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Confinement—A Suppression Response for the Future?

Francis Mohr and Bob Both

Editor's note: The authors of this article shared Incident Commander duties for the duration (August through October 1994) of the Granite Fire discussed here and were involved in the management decisions.

The Granite Fire was one of 60 wildfires ignited by a thunderstorm that passed through the north portion of the Wallowa-Whitman National Forest on August 28, 1994. The fire was located in wilderness within the Hells Canyon National Recreation Area (NRA), approximately 7 miles (11 km) below Hells Canyon Dam on the west side of the Seven Devils Mountains in the Idaho portion of the Hells Canyon Wilderness (fig. 1). Usual suppression techniques were initially used on the Granite Fire, but because there were many other fires at the time that had "higher priority," there was a limited amount of suppression resources available.

The initial suppression efforts by helitack and retardant drops were not successful—the fire spread approximately 500 acres (200 ha) during the first day. From the start, the fire exhibited a behavior that has historically occurred in the Snake River and Hells Canyon area. Perimeter increases resulted from embers rolling downslope and the resultant rapid spreads upslope. These "runs" were extensive at times but usually were limited to narrow strips because of topographic features that exist in this steep, rocky terrain. Occasional tree torching and spot fires added to fire perimeter increases.

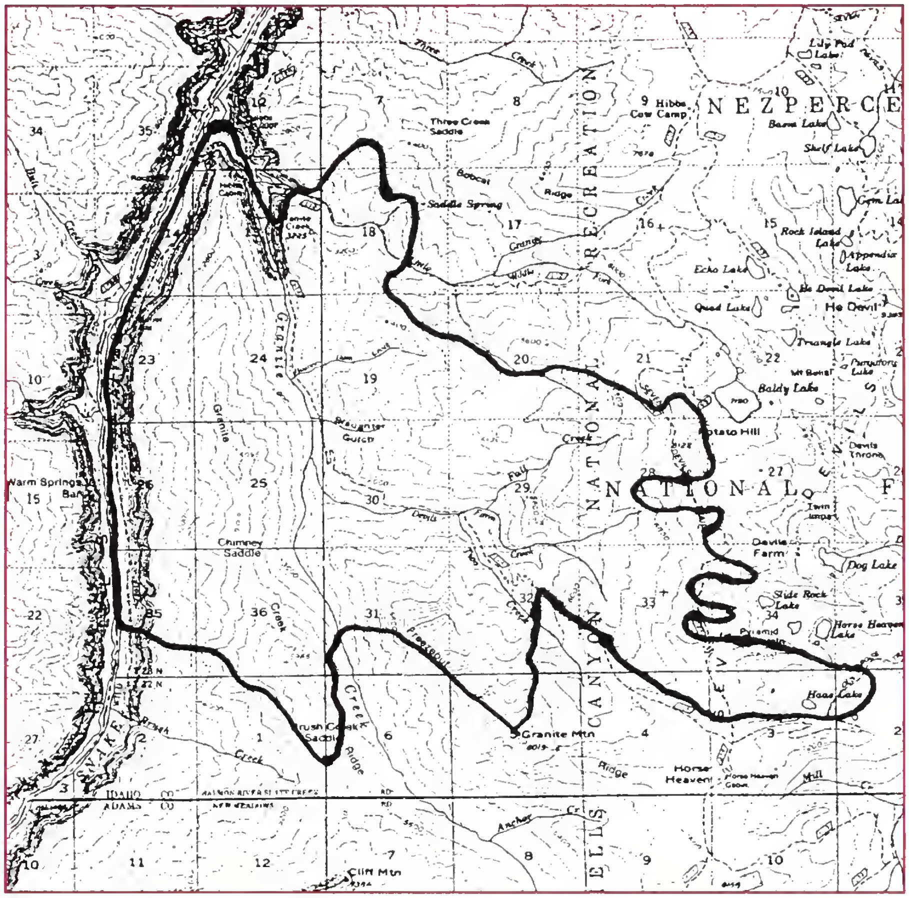

Figure 1—*Map of the Granite Fire in the Hells Canyon National Recreation Area.*

After the Fire Escaped

Once the fire escaped, management used the Escaped Fire Situation Analysis (EFSA) to evaluate what had occurred and to help plan the future management of the Granite Fire. The first EFSA on August 29 selected confinement as the appropriate suppression response to the Granite Fire. Between September 1 and 3, some containment action occurred along the northern confinement boundary in Little Granite Creek. After that, the only suppression tactic used on this fire was aerial and ground surveillance.

On September 11, a Regional Wilderness Fire Assessment Team (Assessment Team) was requested to

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verify the decision for continued management of this wildfire using confinement. The criteria evaluated in the EFSA and reevaluated by the team are discussed here in the order presented in the EFSA.

Potential Fire Behavior and Firefighter Safety. During the initial attack, several firefighters were temporarily trapped on a rock ledge by the fire. They were retrieved safely, but fire managers were concerned about firefighter safety and the potential for more erratic fire behavior. They subsequently identified a confinement boundary that was more defensive and safer for halting fire spread or that would allow the fire to be confined naturally (e.g., by changes in fuel situations, by topographic features, and/or by fall precipitation).

Wildfire Suppression Costs. Fire behavior specialists on the Granite Fire estimated that it would cost $500 to $750 per day to manage the Granite Fire using the confinement strategy with aerial surveillance and occasional onsite monitoring. However, if direct control attack had been continued, they estimated the cost to be considerably more for a number of reasons, including that the area is not easily accessible and considerable helicopter use would be required.

During the previous 30 years in the Hells Canyon area, the array of average costs for direct attack control of wildfires of various sizes had been as follows:

Size range in acres (ha)	Cost range
1-10 (.4-4)	$1,500-15,000
60-160 (24-65)	$14,000-90,000
1,400-6,000 (600-2,400)	$480,000-1,900,000
16,000 (6,000)	$2,500,000

Potential Resource Damage. The Wilderness Act of 1964 (16 U.S.C. 1131-1136) is very explicit that natural processes prevail and allow the changes that occur over time. Fire is one of the natural elements that initiates or facilitates several natural processes in a forest ecosystem. Once the Assessment Team was present, they pointed out that the Granite Fire was not detrimental to the wilderness resource and the potential for resource damage is often directly related to the amount and kind of human activity that occurs during suppression.

We need to communicate to fire managers and the public the need for an appropriate suppression response for wildfires in the wilderness.

Offsite Concerns. The managers knew that if the fire advanced beyond the south-southeast perimeter, as identified in the EFSA, onto the Payette National Forest, it would cause more management stress for a forest already overloaded with wildfire suppression activity. In addition, the fire would exceed the wilderness boundary and enter an area with different management and resource objectives. It would also become a threat toward private property and an ongoing commercial operation at the Red Ledge Mine. Another concern was the possibility of the fire advancing beyond the designated eastern confinement boundary into the Rapid River watershed that supplies water for a downstream salmon hatchery. Finally, there was an "area closure" that restricted both recreational and hunter use in the fire area. Bow hunting season for elk was to open in another week.

Public Concern. Because in the past, particularly in 1989, large fires and/or fires burning for an extended period caused local public concern about Forest Service wildfire management policy, the Assessment Team knew public pressure must be taken into consideration in planning the management of the Granite Fire. They asked whether, as suppression resources became available, public concern would generate enough political pressure to overrule the other evaluation criteria and force the agency into a more costly suppression response.

RERAP and the Probability of Fire Spread

The Assessment Team estimated the probability of fire spread during the remainder of the fire season by using the Rare Event Risk Assessment Program (RERAP) (Wiitala and Carlton 1994) to evaluate historic weather data for the last 30 years from a nearby weather station. RERAP, a relatively new risk analysis tool, was used in conjunction with BEHAVE (Andrews 1986).

Climatological data for the past 30 years suggested a 52-percent probability that the fire season might end by September 25, a 37-percent

chance the fire season could extend into October, and only a 17-percent chance it would extend beyond October 10.

The Assessment Team looked at the probabilities of fire movement for the next 30 days and found that there was a 10-percent probability that the fire would spread 1 mile (2 km) to the south-southeast in the direction of the wilderness boundary. There was only a 28-percent probability the fire would advance 1 mile to the east in this 30-day period.

Based upon information provided by this analysis, it appeared very likely that the perimeter advancement—even if as much as a mile—would remain within the confinement boundary as delineated in the EFSA. Thus, management decided to continue using a confinement suppression response because it was unlikely that the wildfire would threaten previously discussed "offsite concerns" such as the Red Ledge Mine or the Rapid River watershed. The area closure was lifted, an information dissemination process initiated, and both aerial and ground surveillance continued.

Fire Behavior Chronology

After a moisture event on September 13, most fire behavior was typified by a smoldering-type fire in the 1- to 2-inch (3- to 5-cm) duff layer and occasional open flame in the smaller diameter size woody fuels. As a warming and drying trend prevailed, more open flame was noticed, along with increased smoke volume throughout the fire area, suggesting the fire had spread into additional unburned fuels in the area (fig. 2).

Late in the evening of September 20 as the fire torched and spotted through a sparse open stand of whitebark pine, it reached the eastern confinement boundary as designated in the EFSA near the top of Pyramid Mountain. On September 28, a spectacular "run" that paralleled the September 20 event occurred and again reached the confinement boundary. The initial stages that led to this September 28th event were 1) the edge of the fire perimeter had advanced upslope 1/2 mile (.8 km) from the Devils Farm Creek drainage, 2) the fire edge, because of this advancement, was in a more dense stand dominated by subalpine fir, and 3) the edge was at an elevation where it was more exposed and could be better influenced by winds. Overall, a warming and drying weather trend had prevailed from the 20th to the 28th, and both dead and live fuels were very receptive for quick ignition and heat-intensity buildup.

When a few trees torched in midafternoon on September 28, the stage was set. A convection column quickly developed (fig. 3). The fire contributed to its own behavior. As a precautionary measure, an administrative cabin 1/3 mile (1/2 km) to the southeast of this fire activity was covered with aluminized fire shelters.

As this fire "run" made its way toward the cabin, it was influenced by strong south-southwesterly winds, changed direction, burned to the top of the ridge, and spotted outside the confinement boundary into the upper portion of the Haas Lake Basin.

Fire within the Haas Lake Basin remained active throughout the night until rain started at approximately 0430 hours on September 29. Nearly 90 percent of the subalpine fir and whitebark pine stand in the basin was killed by sporadic torching that occurred throughout the night.

Occasional tree torching was again observed in the Haas Lake Basin on October 8 and 9, and on the 10th there was continuous torching of dead standing spruce. Rain

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Figure 2—*Increased fire activity noted as warming and drying trend followed rain on September 13. Photo: Francis Mohr, USDA Forest Service, 1994.*

Figure 3—*The convection column that developed on September 28. Photo: Francis Mohr, USDA Forest Service, 1994.*

on the evening of the 10th continued throughout the night, and 2 days later, snow ended the fire season. The fire was declared controlled on October 13.

Acreage increase from September 11 until the end of the fire was an additional 1,924 acres (779 ha). Approximately two-thirds of this increased acreage was along the east side of the original fire edge. The remaining one-third was mostly along the north-northeast perimeter and a small amount along the southern perimeter. The final size of the Granite Fire was 9,116 acres (3,689 ha) with the majority of the area being a low-intensity surface burn. There were only scattered areas of high-intensity, stand-replacement fire.

Confinement Management Strategy

The original confinement boundary was evaluated through the EFSA four times and revised twice, but the strategy of "confinement with limited action" remained the same. On September 26, the first boundary adjustment moved the northern confinement boundary upslope to Bobcat Ridge—instead of the stream bottom of Little Granite Creek. The feeling was that if the fire spread to the north and crossed Little Granite Creek, a more defensible area to manage the spread, either naturally or with water bucket drops, would be the more open grass-brush area between Little Granite Creek and Bobcat Ridge.

The second boundary adjustment occurred on September 30, after the fire perimeter advanced beyond the eastern designated confinement boundary and spotted into the Haas Lake Basin. The confinement boundary was adjusted to coincide with the Old Boise Trail. During onsite surveillance on October 1 and 3, several small spot fires were observed located just below the Old Boise Trail in a boggy area of lodge-pole pine and spruce. With the predicted forecast, no adjustment in the confinement boundary was deemed necessary. On October 10, spot fires below the Old Boise Trail spread into dead standing spruce, resulting in continuous torching until early evening. No suppression action or adjustment in the confinement boundary was initiated because a moist weather system had already reached the western edge of the forest.

Energy Release Component

The Energy Release Component (ERC) of the National Fire-Danger Rating System provided some interesting comparisons with the observed fire activity and behavior. Using weather data collected by a Remote Automatic Weather Station (RAWS) site at the Harl Butte lookout, management noticed that the ERC continued to climb steadily following the light moisture of September 13. By the 17th, it was back at the 90th percentile level. This was also the day there was a noticeable increase in fire activity—no major "runs," but there were more tree torchings and increases in the amount of smoke throughout the fire perimeter. The afternoon and evening of September 20, when the fire was very active and the perimeter was extended to the confinement boundary, the ERC was at the 97th percentile level. From September 21 through the 28th, each day continued to have the highest ERC on record for that date for the past 30 years at Harl Butte. Correspondingly, the fire was active each day, torching and making small runs. On September 28th, when the fire made a major run beyond the confinement boundary and into the Haas Lake Basin, the ERC was the highest ever recorded by the Harl Butte Weather Station (fig. 4). Fire activity within the Haas Lake Basin remained active throughout the night until the rain started on September 29.

Following the September 29 rain shower, the ERC again increased as warming and drying prevailed, and it reached the 90th percentile level by October 9. Occasional tree torching was observed on October 8 and 9. On the 10th, there was continuous torching of dead standing spruce just below the Old Boise Trail, resulting in a convection column that was visible from the town of Enterprise 32 miles (51 km) to the west.

Comparative Costs

Costs associated with the three suppression phases were:

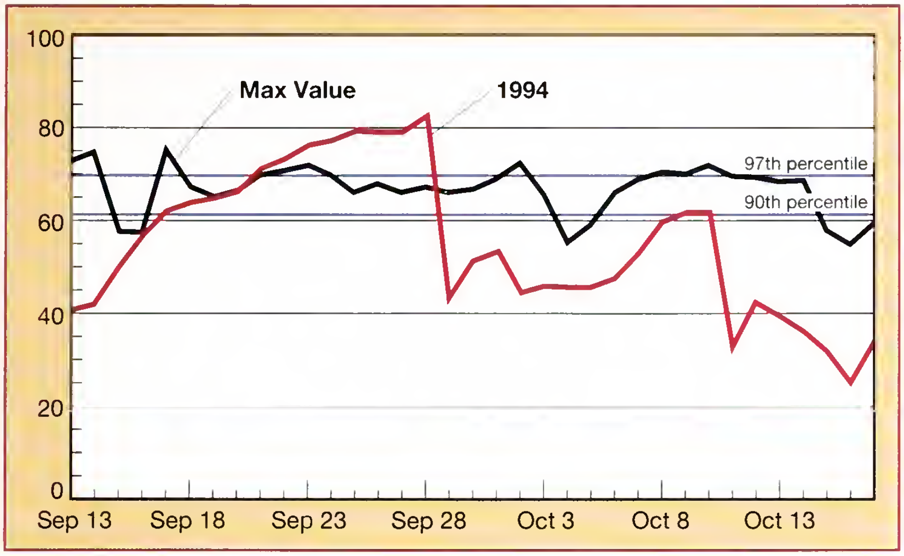

Figure 4—*A comparison of the Energy Release Component at Harl Butte weather station with the highest observed fire activity and behavior for 30 years.*

- Initial attack on August 28 (e.g., helitacks and retardant) was $13,213;
- Containment and confinement from August 29 through September 10 (e.g., Type I helicopters and bucket drops) was $295,819; and
- Continued confinement from September 11 through October 14 (e.g., aerial and onsite surveillance) was $38,212

for a total of $347,244.

When average suppression costs for a fire of this size in the Hells Canyon area during the last 30 years—between $1,900,000 and $2,500,000—are compared with the above total cost of $347,244, it is easy to see how much money was saved by using a confinement strategy.

The Future of Containment and Confinement

Although it is now clearly evident that the confinement and containment suppression response proved to be the least cost approach and was most compatible with the wilderness resource, the Hells Canyon NRA manager expressed a concern that deserves consideration. He pointed out that this wildfire was from a multi-ignition storm, and because of other nonwilderness fires in the area, there were limited suppression resources. In addition, the Granite Fire was ranked as low priority for suppression because of its rapid fire-behavior activities, unsafe firefighting conditions, and its low land value as a wilderness resource. The NRA manager's concern was that the analysis discussed here and consequent confinement suppression response would not have occurred if the Granite Fire had been the only wildfire ignited by the storm.

It is clear that if confinement as a management approach had not been selected, then education of line officers and fire managers is essential if containment and confinement are to be suppression responses for wildfires in the future. To incorporate the use of the appropriate suppression response into fire management as part of ecosystem management, those with experiences managing fires in wilderness must pass this information along to those coming up through the ranks.

Fire Has Helped Manage the Ecosystem

When managers evaluate the landscape mosaic created by wildfires in this portion of the Hells Canyon Wilderness during the past 8 years (fig. 5), there is no doubt they will use confinement strategies for wildfires in wilderness areas as well

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Figure 5—*Mosaic created by Hells Canyon fires. Photo: Francis Mohr, USDA Forest Service, 1994.*

as prescribed natural fires (PNF's) in the future. Reduced surface fuel loadings (resulting in less heat intensity during a fire) combined with natural firelines (created by scattered areas of total stand-replacement burns) have lessened the chance that a wildfire will escape from the wilderness onto wildlands that are regarded as having a higher economic value. In the last 8 years, fuel reduction and/or creation of natural fuelbreaks have occurred on more than 34 percent of the landscape in this 77,023-acre (31,170-ha) portion of the Hells Canyon Wilderness.

Conclusions

Lessons and considerations learned from confinement management of this Granite Fire include:

- Confinement strategy can greatly reduce exposure of personnel to safety hazards,
- Confinement strategy can significantly reduce wildfire suppression costs,
- Suppression can be achieved with significantly less resource damage,
- Postburn effects can lessen risk of future PNF escapes,
- A wilderness wildfire Assessment Team using RERAP can be an asset in the evaluation of the EFSA,
- Because there was no negative feedback, it is highly likely that there is public support for this type of suppression response strategy in some areas, and
- Continuation of a proactive information program concerning the appropriate suppression response is essential, but to date this fostering of more understanding on the part of the public and fire managers has not occurred.

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Any technical questions should be directed to Ralph H. Gonzales, USDA Forest Service, San Dimas Technology and Development Center, 444 East Bonita Avenue, San Dimas, California 91733, telephone 909-599-1267, extension 212. ■

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Rx Fire Research for Southwestern Forests

David R. Weise, Stephen S. Sackett, Timothy E. Paysen, Sally M. Haase, and Marcia G. Narog

Information from research can aid resource and fire managers in planning prescribed fires in forests and woodlands in the Southwestern United States. Researchers at the Prescribed Fire Research Work Unit in Riverside, CA, have studied long- and short-term effects of prescribed burning in several different forest types. This article illustrates the beneficial and detrimental effects associated with the planned reintroduction of fire into southwestern forests. Lessons learned from these long-term studies may also be applicable to other semiarid forests in the Western United States.

Two long-term studies have comprehensively examined prescribed fire use in southwestern ponderosa pine in Arizona and in canyon live oak in California. Short-term research has addressed fire effects in singleleaf and common pinyons, Jeffrey pine, sugar pine, giant sequoia, and California black oak. Ponderosa, sugar, and Jeffrey pines constitute the majority of the long-needled pine forest types with short fire-return intervals in the Western United States (Williams 1995). Prescribed fire has been proposed as a tool to manage the fuels in these short fire-return interval forests.

David R. Weise, Stephen S. Sackett, Timothy E. Paysen, and Sally M. Haase are research foresters and Marcia G. Narog is an ecologist, USDA Forest Service, Pacific Southwest Research Station, Riverside, CA.

To prevent hazardous wildfires in the future, we need to reintroduce fire into western forests to reduce understory fuel buildups.

Southwestern Ponderosa Pine

We have been studying the effects of repeated prescribed burning on southwestern ponderosa pine areas in two experimental forests in Arizona since 1976. An objective of our study was to determine a fire-return interval that would keep fuel accumulations at nonhazardous levels. Fire-return intervals of 1, 2, 4, 6, 8, and 10 years have produced a variety of stand conditions. Also, we studied the impacts of regular fall burning on ecosystem components such as nutrient cycling, plant succession, overstory survival, natural regeneration, and air quality.

The initial fires were conducted at night to protect the overstory; they substantially reduced the forest floor fuels that had accumulated for nearly 100 years. This fuel had accumulated because of low decomposition rates in these arid and semiarid forests. Subsequent burns illustrated the varying effects of weather on prescribed burning. Annual fall burning—not necessarily a practical operational tool—appears to require warm, windy

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Rotational prescribed burning in southwestern ponderosa pine. Photo: J. H. Dieterich, USDA Forest Service (retired), Tempe, AZ, 1995.

conditions in Arizona. Longer interval plots (e.g., 4-year) have burned well under less than optimum conditions.

Repeated burning has thinned the understory as well as the overstory. In some instances, overstory and understory mortality resulted from crown damage caused by moderate to extreme fire behavior. We suspect that root mortality and basal girdling—the result of long-duration, elevated soil temperatures from smoldering combustion in forest floor fuels—are important causes of overstory decline and mortality, even though the damage is not readily visible. Needle litter and sloughed bark accumulate around the root crowns of larger trees; this material may smolder for several days, releasing a great deal of heat into the soil and root crown. Low intensity prescribed fires may inadvertently cause unacceptable mortality when fire is initially reintroduced into an area that has not burned nor been disturbed substantially.

Nitrogen is a limiting factor on some semiarid ponderosa pine sites. Prescribed fire releases the nutrients stored in the dead needles and branches into the soil and air. Available nitrogen levels in the soil have increased after fire, effectively fertilizing the stand. This effect is short-lived, but repeated burning continually releases the stored nitrogen, which is used by both overstory and understory vegetation.

Natural regeneration increased substantially after reintroducing fire into these ponderosa pine stands because a mineral soil seedbed was created. Seedlings have survived repeated burning on some of the longer rotations. Dense, stagnated sapling stands have been thinned by repeated prescribed burning. Research findings indicate that appropriately applied prescribed burning is an ecologically necessary and appropriate management tool in southwestern ponderosa pine.

Reintroducing fire into a canyon live oak forest. Photo: Marcia Narog, USDA Forest Service, Pacific Southwest Research Station, Riverside, CA, 1985.

Canyon Live Oak

Canyon live oak, the most widely distributed oak in California, is an important source of fuelwood and wildlife habitat in southern California. Because of site and stand characteristics such as high fuel loadings and steep slopes, canyon live oak is susceptible to and may be readily top-killed by wildfire. In southern California, this oak occurs elevationally between chaparral and ponderosa/Jeffrey pine stands. Fuel breaks may be potentially located in the canyon live oak zone to protect the pine forests from wildfires spreading out of the chaparral.

We tested the ability of prescribed fire and thinning to create a shaded fuel break in canyon live oak at one study location in the San Bernardino National Forest in southern California. The site was thinned in 1984, and the slash was allowed to cure until November 5 to 7, 1985, when the plots were burned. Weather conditions at the site changed quite rapidly during this burning period. A Santa Ana wind (foehn wind) occurred on November 6, followed by snow fall on November 8. Weather conditions typically change quite rapidly in southern California and Arizona at that time of the year, making prescribed burning challenging.

Canyon live oak survival and growth have been monitored since the initial prescribed burns. As is often the case with prescribed burning, the fire treatment essentially caused a "thinning from below" in which most of the mortality occurred in the small diameter trees. Partially in response to the fire, many trees sprouted near the root crowns. This profuse sprouting enhanced forage for many wildlife species. Even though the trees were stressed by a 6-year drought shortly after the prescribed fires, virtually all mortality

occurred within the first 2 years after the fires. The few large trees that died may have been killed by a combination of factors. In addition to crown scorch, root crown damage caused by smoldering combustion in the accumulated leaf litter at the base of the trees may have girdled them. On the basis of the low mortality observed in this study, prescribed fire might be used to reduce fire hazard in canyon live oak and to create a shaded fuel break.

Fire Reintroduction

The need to reintroduce fire into western forests to reduce hazardous fuel buildups and restore the role of fire in these forests is generally accepted. However, prescribed fire is not a panacea. Accumulated forest floor fuels in forests where decomposition is very slow may present as great a fire hazard to the overstory trees as do the accumulated woody and ladder fuels. In addition to the mortality observed in southwestern ponderosa pine and canyon live oak, we have also observed mature sugar and Jeffrey pines dying after the reintroduction of fire. We suspect this is primarily caused by severe root damage or girdling.

We have measured elevated temperatures of more than 100 °F (38 °C) several inches below the soil surface, even though the flames are only a few feet long. These elevated temperatures result from smoldering combustion and probably kill fine roots. Root mortality and root crown girdling of dominant trees are potentially two undesirable effects that fire and resource managers should consider when designing fire prescriptions. Alternatively, fire prescriptions may be designed to promote mortality if creating snags and cavity trees for wildlife is an objective.

Summary

Long-term prescribed fire research in southwestern ponderosa pine and canyon live oak has yielded information useful to fire and resource managers of southwestern forests. Prescribed fire has had beneficial and detrimental effects in the stands we studied. Both types of effects should be considered when contemplating prescribed fire to reduce the accumulated fuel hazard in southwestern forests.

For more information about these research results, contact the Prescribed Fire Research Work Unit, 4955 Canyon Crest Drive, Riverside, CA 92507, tel. 909-276-6523, fax 909-276-6426. We plan to provide some of this information on the Internet at http://www.rfl.pswfs.gov/index.html sometime in 1996. This home page can also be accessed via the Pacific Southwest Research Station's home page: http://www.pswfs.gov.

Literature Cited

Williams, Jerry. 1995. Firefighter safety in changing forest ecosystems. Fire Management Notes. 55(3): 6-8. ■

1997 Wildland Fire Conference in Canada

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Jill R. Style

The 2nd International Wildland Fire Conference will be held from May 25 through 30, 1997, in Vancouver, British Columbia. The conference's principal sponsor is the North American Forestry Commission's Fire Management Study Group.

This conference will bring together speakers and exhibits from around the world to foster international cooperation and to share information on wildland fire issues. Both the public and private sectors will be represented in discussions of fire management strategies and programs. Sustainable development of forest resources will also be a major focus of the five conference sessions.

In addition to panel discussions, poster sessions, and hands-on demonstrations throughout the conference, there will be a trade show to showcase the latest in firefighting equipment and technology.

For more information, please contact the Conference Secretariat, Events by Design, 601-325 Howe Street, Vancouver, BC, Canada V6C 1Z7. Telephone 604-669-7175 or fax 604-669-7083. ■

Jill R. Style is a volunteer for the USDA Forest Service, North Central Forest Experiment Station, East Lansing, MI, and was assistant editor and intern for Fire Management Notes *from January through April 1996.*

FEPP? What in the World Is FEPP?

April J. Baily

Overheard in a coffee shop in a small town somewhere in the Midwest: "We're having so many problems getting firefighting equipment. I've been thinking we should see about getting FEPP." The response: "'Fep'? I've never heard of 'fep.' Is it contagious?"

April Baily is the general manager of FMN and is the national program manager for Federal Excess Personal Property, USDA Forest Service, Fire and Aviation Management, Washington, DC.

A collage of Federal Excess Personal Property (FEPP) in service throughout the United States. Photos: USDA Forest Service, F&AM, Washington, DC.

The respondent can be forgiven for misunderstanding the term. FEPP is not a part of the average American's working vocabulary. FEPP is an acronym for Federal Excess Personal Property and is a handy nickname for the property acquired from other Federal agencies by the USDA Forest Service for subsequent loan to one of the 50 State Foresters or their counterparts in eight territories. The property includes aircraft, welders, semitractors and semitrailers, pickup trucks, 4- and 6-wheel-drive trucks, all-terrain vehicles, Gamma Goats, sheet metal, nuts, and of course, bolts. All of it is used to fight fires in rural areas.

The process starts with a cooperative agreement between a State Forester and the USDA Forest Service and continues with similar agreements between the State Forester and local rural fire districts. FEPP provides a source of firefighting equipment that many fire districts could not otherwise afford.

Each State has a different approach to the acquisition of FEPP, but in general, a State representative will visit local military bases and other Federal facilities that have unused property. This employee will screen (or identify) those items that can be used directly or modified for use in firefighting. After approval by the holding Federal agency, the Forest Service, and the General Services Administration, the property is transferred to the ownership of the Forest Service and released to the custody of the State.

An example of equipment available through FEPP is this Gamma Goat with roll-over protection pulling a tank of water for the State of Hawaii. Photo: USDA Forest Service, F&AM, Washington, DC.

Much of this property is used within the State's own wildland fire program; other items are subsequently loaned by the State to rural fire departments. These local departments use the equipment to provide fire protection. In return, they maintain the equipment, protect it from misuse and abuse, make it available for inspection by either the State or the Forest Service, perform physical inventories every 2 years, and return it to the State when the equipment either is no longer needed or is not economically repairable.

So! How **would** a local fire chief obtain FEPP? The first step is to contact the appropriate State Forester. A list of all the State Foresters with telephone numbers and addresses is available from the National Association of State Foresters, 444 N. Capitol Street NW, Suite 540, Washington, DC 20001; telephone 202-624-5415. ■

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